

ECOLOGICAL CLASSIFICATION OF FOREST-DWELLING CARABIDAE (COLEOPTERA) IN THE NETHERLANDS

by

HANS TURIN

Esdoorndreef 29, 6871 LK Renkum

and

THEODOOR HEIJERMAN

Vakgroep Entomologie, Landbouwwuniversiteit, Wageningen

ABSTRACT

As a first part of a study considering the carabid fauna from different kinds of forests in the Netherlands, the Dutch species were classified as to their degree of affinity with forest biotopes. For this we employed a method making use of data from pitfall catches originating from about 900 different localities and consisting of over 1650 samples. Different levels of affinity were recognized and defined and the carabid species were classified into ecological groups based on these levels.

INTRODUCTION

Den Boer (1963, 1968) presented the results of a study concerning the carabid faunas of forests in the province of Drenthe. Amongst other things he concluded that the fauna of coniferous forests only constitute an impoverished reflection of the fauna of deciduous forests. We have carried out a general survey of the carabid fauna in several forests in the central and southern parts of the Netherlands to test this conclusion. While working on our data, we felt the need for a classification of the Dutch carabid species according to their affinity with these biotopes. The present paper deals with the results of a classification, while the results of the general survey will be presented later (Heijerman & Turin, in prep.).

Many investigations have already been carried out on this subject. Papers on the composition of forest faunas (e.g. Den Boer, 1963, 1968; Van der Drift, 1959; Lauterbach, 1964; Lohmeijer & Rabeler, 1965; Rabeler, 1962, 1963, 1967 and 1969 and many others), were reviewed by Thiele (1977), who presented an important survey of the occurrence of carabid species in different kinds of forest in Central and Western Europe.

Den Boer (1977) published the results of a nine year study of carabid populations in various biotopes in the province of Drenthe in the north-eastern part of the Netherlands. This extensive survey, although restricted to a part of the Netherlands only, significantly increased our knowledge on dispersal power and habitat relations of many carabid species. Recently, investigations into the carabid forest fauna were carried out by Heckendorf et al. (1986), Lecordier & Benest (1982), Loreau (1984a, b, c, 1985, 1986) and Szyszko (1983). Due to geographic variation in ecological preferences of many species, ecological classification of species is meaningful only for well-defined and restricted areas. However, the data on which such a classification is based should be extensive and representative for the area. Moreover, the criteria for classification should be explicitly stated and be unambiguously defined. In this paper an effort is made to classify the Dutch carabid species (cf. Turin, Haek & Hengeveld, 1977), in relation to their affinity with forest habitat. The results will be used for the study mentioned above. In due time we will also present a classification of the Dutch carabids considering a much greater variety of biotopes.

Table 1. Values of T and Y. Values of Y calculated for different values T (see text for further explanation). Lines represent the boundaries between the main categories distinguished.

T	Y (%)
10	75.1%
9	73.1%
8	70.1%
7	67.8%
6	64.4%
5	60.1%
4	54.5%
3	47.5%
2	37.6%

METHODS

The basic material used for this study consists of about 1650 samples from pitfall sampling at about 900 localities all over the Netherlands. At each locality a series of 3-10 pitfalls were used. As part of a national carabid project (Turin & Penterman, 1985), all data resulting from pitfall trapping were collected and stored in a database. Only those pitfall catches that resulted from continuous trapping during a whole year or at least during the reproductive period (March-October) were selected for our analysis. The final database includes information about 1.5 million individuals. All pitfall localities were characterized by means of an ecological code, as used by the European Invertebrate Survey - Netherlands (Van Tol, 1979). This code includes information about soil type, humidity, vegetation structure and type of habitat. Forests were defined as biotopes where trees dominate the vegetation, thus excluding scrub vegetations, forest edges, hedges, wooded banks, wind-breaks or other small groups of trees. For this study we have used two criteria by which we quantify the affinity of a species with forest biotopes. Criterion A is the number of individuals of a species present in the forest samples, expressed as a percentage of the total number of individuals of the species in all samples together. Criterion B is the number of forest samples in which the species is present, expressed as a percentage of the number of samples in which the species occurred. Criterion B will be rather vulnerable to accidental occurrences of one or only a few individuals of a species in a sample, which is the reason to consider criterion A the most suitable for our purposes. For the application of both criteria it seems crucial that the forest samples are well

represented among the number of samples available, and also other habitat types should be sufficiently represented. Our data do indeed satisfy this condition; 384 series (=23.2%) originate from forests. The remaining series were placed in: scrub vegetation (8.6%), heath vegetation and moors (21.0%), grasslands including salt marshes (30.4%), various vegetation with herbs (5.1%), bare grounds and dunes (5.1%), waste land and agricultural land (12.2%).

The number of times (T) a species occurs more often in one habitat than in the remaining types of habitat together, has been used as a measure of its affinity with that habitat. Den Boer (1977: 41) presents a formula which calculates the minimum percentage (Y) of the total number of specimens that should be present in the samples of a certain habitat, to consider the species typical for that type of habitat:

$$Y = (100 * T * k) / (T * k + \text{Tot} - k)$$

where Y and T are as defined and Tot represents the total number of samples and k the number of samples in the habitat type under consideration. One may determine limits between categories differing in degree of (forest-) biotope affinity, by arbitrarily choosing certain values for parameter T. In his study Den Boer considered a species typical/characteristic for a certain type, if its mean number of individuals present in the samples of that habitat, is at least four times as high as in the remaining samples (X) (Den Boer 1977: 41), thus using $T=4$. It is clear that the values of Y will range from approximately 0%, in cases where the number of samples of the habitat type considered, only constitute a minor proportion of the total number of samples over all habitat types, up to 100%, in cases where all samples originate from the same type of biotope. Note that the formula does not take into consideration the number of alternative types, nor the distribution of the samples over the remaining biotope types.

In table 1 we present the values of Y calculated for different values of T. It must be stressed that there exist no 'natural' criteria by which to delimit categories of different affinity to a (forest) biotope. We have arbitrarily chosen the main ecological categories to be limited as indicated in table 1. Thus, a species occurring ten times as often in forests as compared with non-forests, is considered, by definition, a stenotopic forest species. Species occurring four to nine times as often in forest habitats,

Table 2. Ecological categories. Criteria for the division into ecological categories. Criterion A: the number of individuals of a species, present in the forest-samples, expressed as a percentage of the total number of individuals of the species in all 1658 samples together. Criterion B: the number of forest-samples in which the species was present. See text for further explanation.

MAIN ECOLOGICAL GROUP	Criterion A	SUBGROUP	Criterion B
Stenotopic forest species	> 75%	S-I S-II	75% 50-75%
Eurytopic forest species	50-75%	E-I E-II	50-75% 30-50%
Borderline species	30-50%	—	—
Non forest species	< 30%	—	—

are considered eurytopic species. Species occurring less than two times as often in forest habitats as compared with the remaining habitats, are non-forest species, while species that occur two to three times as often in forest habitats constitute the borderline species. The limits as presented in table 1, determine the critical values of criterion A. Thus a species with a value of A greater than 75%, belongs to the stenotopic forest species, etc. We have used criterion B to discriminate further within the two main categories of stenotopic and eurytopic forest species. Species with a high value for criterion B will seldom be caught outside forest habitats. A low value of B indicates that the species may often be trapped in non-forest habitats. Table 2 shows the recognized ecological categories, and the way in which they were defined.

In the following paragraphs, nomenclature used is according to Silfverberg (1979) and Lindroth (1985, 1986).

RESULTS

Table 3 presents the carabid species that must be considered stenotopic forest species according to our two criteria. The first part of table 3 lists the S-I species of table 2 and the second part the S-II species. The criteria could not be applied to a number of species that should be considered stenotopic forest species based on data from the literature (Thiele, 1977 and references cited by him; Lindroth, 1945, 1974, 1985 and 1986), because they were very rare among the pitfall catches viz.: *Calosoma inquisitor* (Linnaeus), *Carabus auronitens* Fabricius, *Dromius angustus* Brullé, *Molops piceus* Panzer, *Pterostichus cristatus* (Dufour) and *Trichotichnus nitens* (Heer). Furthermore there are some stenotopic forest species that were not caught in pitfall traps at all. These are either very rare in our country or even became extinct during this century e.g.: *Abax ovalis* (Duftschmid),

Calosoma sycophanta (Linnaeus), *Carabus glabratus* Paykull, *Carabus intricatus* Linnaeus, *Dromius fenestratus* (Fabricius) *Dromius quadrisignatus* (Dejean) and *Trichotichnus laevicollis* (Duftschmid) (see also table 6).

See table 4 for a listing of the eurytopic forest species. *Agonum livens* (Gyllenhal) (Table 6), probably must be considered an eurytopic forest species (Lindroth 1945, 1974 and 1986), but it was caught in such low numbers in pitfalls, that the assignment criteria could not be applied.

Figure 1 shows a graphic representation of the way in which the four recognized categories of forest species were defined, using both criteria A and B. For one species only, *Calathus micropterus*, criterion A has a lower value compared with the value of B. This means that this species only occasionally occurs in other than forest biotopes, but that it may be very abundant there at the same time. From our data it indeed appears that *C. micropterus* has an ecological optimum in both coniferous forests and in vegetations of the Corynephorum.

In table 5 the borderline species are presented. *Pterostichus quadriveolatus* Letzner, clearly is associated with forest biotopes (Lindroth, 1945, 1974 and 1986), but more than 47% of the individuals was caught in pitfalls placed on forest clearings and areas with burned trees.

A few species remain to be mentioned here because they frequently appear in other biotopes with trees, such as hedgerows and water meadow forests. *Agonum obscurum* (Herbst) can be characterized as a species, living in all kinds of shady, moderately moist places; 93 % of the individuals of *Bembidion mannerheimi* C.R. Sahlberg were

Table 3. Stenotopic forest species. I = Total number of individuals present in all 1658 samples together. A: percentage of I, caught in forest habitats. II = Total number of samples in which the species was present. B: percentage of II, belonging to forest habitats. Upper part S-I species, lower part S-II species, see table 2 and text for further explanation.

SPECIES	I	A (%)	II	B (%)
<i>Dromius agilis</i> (Fabricius)	28	96.4	21	95.2
<i>Leistus rufomarginatus</i> (Duftschmid)	3485	95.7	204	86.3
<i>Harpalus quadripunctatus</i> Dejean	1805	93.8	87	79.3
<i>Cychnus caraboides</i> (Linnaeus)	347	90.5	93	87.1
<i>Abax parallelus</i> (Duftschmid)	1916	89.5	46	86.9
<i>Dromius spilotus</i> (Illiger)	15	86.7	10	80.0
<i>Notiophilus rufipes</i> Curtis	4353	86.0	205	77.1
<i>Amara pseudocommunis</i> Burakowski	164	84.8	30	83.3
<i>Calathus rotundicollis</i> Dejean	5559	84.1	231	80.9
<i>Amara brunnea</i> (Gyllenhal)	3269	96.8	74	74.3
<i>Leistus fulvibarbis</i> Dejean	196	91.3	23	60.9
<i>Pterostichus oblongopunctatus</i> (Fabricius)	46750	85.6	370	69.6
<i>Abax parallelepipedus</i> Piller & Mitterpacher	24343	84.0	282	58.2
<i>Carabus nemoralis</i> O.F. Müller	7619	80.8	326	65.6
<i>Trechus secalis</i> (Paykull)	1063	78.1	14	64.3

caught in willow shrub; and *Patrobus atrorufus* Stroem lives in moist woodlands and hedgerows especially in the water meadows along the large rivers.

For sake of convenience, table 6 finally presents all the above mentioned species that are known from the literature to have more or less strong affinities with forest habitats, but that could not properly be classified in any of the categories distinguished by us.

Summarizing these results, 15 species of Dutch forest-dwelling Carabidae can be regarded as stenotopic forest species and 14 as eurytopic forest species, while five species belong to the borderline cases. Species whose occurrence in the Netherlands

is doubtful, or which could not be classified by means of our criteria, are disregarded.

DISCUSSION

In the following we will shortly discuss some of the discrepancies that exist between our results and findings of some authors. In general the stenotopic forest species of our category S-I (table 2), are also reported in the literature as being species with strict forest affinities. However, not all of the carabid species classified in group S-II (table 2), are really characteristic to tall forests of the (sub)-centreuropic type. Thiele (1977) classified the species *Abax parallelepipedus*, *Carabus nemoralis* and *Pterostichus oblongopunctatus* among the species with no strict affinity to any type of forest habitat. Species occurring in the tall forests like the Fage-

Fig. 1. Graphic representation of the four categories of forest species recognized, based on the criteria A and B. Each ●—● represents a species, the ● indicating the respective values for A and B. See tables 3, 4 and text for further explanation.

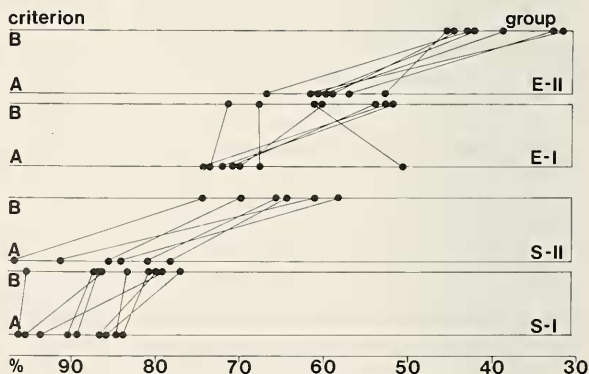


Table 4. Eurytopic forest species. Upper part E-I species, lower part E-II species, see table 3 and text for further explanation.

SPECIES	I	A (%)	II	B (%)
<i>Carabus problematicus</i> Herbst	16979	74.7	361	52.4
<i>Agonum assimile</i> (Paykull)	3994	73.7	119	71.4
<i>Stomis pumicatus</i> (Panzer)	1745	72.1	178	51.7
<i>Notiophilus biguttatus</i> (Fabricius)	7553	70.9	434	53.9
<i>Carabus violaceus</i> Linnaeus	2098	70.1	119	60.1
<i>Dromius quadrimaculatus</i> (Linnaeus)	34	66.7	27	66.7
<i>Calathus micropterus</i> (Duftschmid)	1567	50.6	95	61.1
<i>Trichocellus placidus</i> (Gyllenhal)	5032	66.9	258	43.0
<i>Nebria brevicollis</i> (Fabricius)	31101	61.8	665	31.6
<i>Badister lacertosus</i> (Sturm)	421	60.8	113	42.5
<i>Leistus spinibarbis</i> (Fabricius)	669	60.0	36	38.9
<i>Leistus terminatus</i> (Hellwig)	953	59.4	230	44.8
<i>Carabus coriaceus</i> Linnaeus	703	57.2	55	32.7
<i>Badister unipustulatus</i> Bonelli	17	52.9	11	45.5

talía of both lowlands and mountains (Thiele 1977), are restricted in the Netherlands to the southern part of the province of Limburg and the eastern most parts of the provinces of Overijssel and Gelderland. they usually occur in forests of the Quercó-Carpinetum type: e.g. *Abax ovalis*, *Carabus auronitens*, *Molops piceus*, *Pterostichus cristatus*, *Trichotichnus laevicollis* and *T. nitens*. Both *T. nitens* and *Abax parallelus* also occur in the cooler types of Quercó-Betuletum forests in the southern part of Limburg, and *A. parallelus* also in the central parts of the Netherlands in Quercó-Betuletum forests with a dense undergrowth especially of *Pteridium aquilinum*.

The eurytopic forest species (table 4) are also reported as dominant forest species in the literature, but in addition they may appear in other biotopes with comparable micro-climatological conditions, especially humidity. Species of this category appear to be inhabiting relatively light forest types or water meadow forests, but also shaded habitats such as hedges, wind-breaks or even grasslands with dense vegetation, etc. In particular species belonging to category E-II, may

sometimes be very abundant in non-forest habitats. *Nebria brevicollis*, for instance is classified here as an eurytopic forest species (table 4), but is also reported as an important species of meadows and pastures (Thiele, 1977) and *Carabus coriaceus* has also been caught in relatively high numbers outside forest habitats.

Many species mentioned by Thiele (1977) as forest species, are not included in our tables. Although they can occur in relatively high numbers in forest habitats, they also may appear in quite different types of habitats which are in no way related to forests; these are very eurytopic species such as *Bembidion tetracolum* Say, *Harpalus latus* (Linnaeus), *Loricera pilicornis* (Fabricius), *Pterostichus melanarius* (Illiger), *P. strenuus* (Panzer) and *Trechus quadristriatus* (Schränk).

The borderline carabids usually seem to favour non-forest habitats, but they sometimes may be very abundant in certain types of forests.

All carabid species classified as forest species by our criteria and also mentioned by Den Boer

Table 5. Borderline species. See table 3 and text for further explanation.

SPECIES	I	A (%)	II	B (%)
<i>Notiophilus palustris</i> (Duftschmid)	1459	49.7	329	42.3
<i>Pterostichus quadrisoveolatus</i> Letzner	2939	47.2	63	68.8
<i>Agonum fuliginosum</i> (Panzer)	698	42.8	171	43.3
<i>Laemostenes terricola</i> (Herbst)	381	38.1	43	39.5
<i>Badister bullatus</i> (Schränk)	688	32.7	229	32.8

Table 6. Unclassifiable species, with uncertain affinities to forest biotopes. Species which are related to forest biotopes but that could not be classified according to our criteria for various reasons (see text).

SPECIES	NOTE	GROUP*
<i>Abax ovalis</i> (Duftschmid)		Stenotopic forest species
<i>Calosoma inquisitor</i> (Linnaeus)	decreased	
<i>Calosoma sycophanta</i> (Linnaeus)	extinct	
<i>Carabus auronitens</i> Fabricius		
<i>Carabus glabratus</i> Paykull	extinct	
<i>Carabus intricatus</i> Linnaeus	extinct	
<i>Dromius angustus</i> Brullé		
<i>Dromius fenestratus</i> (Fabricius)	extinct	
<i>Dromius quadrisignatus</i> (Dejean)	extinct	
<i>Molops piceus</i> (Panzer)		
<i>Pterostichus cristatus</i> (Dufour)		
<i>Trichotichnus laeviscolis</i> (Duftschmid)		
<i>Trichotichnus nitens</i> (Heer)		
<i>Agonum livens</i> (Gyllenhal)		Eurytopic forest species
<i>Agonum obscurum</i> (Herbst)		Borderline species
<i>Bembidion mannerheimi</i> C. R. Sahlberg		
<i>Patrobus atrorufus</i> (Ström)		

* Concluded from data from the literature.

(1977), belong to his category D (wood species). Den Boer, however, also classified our borderline species *Agonum fuliginosum*, *Badister bullatus*, *Notiophilus palustris* and *Pterostichus quadrifoveolatus*, as D-species and even our non-forest species *Loricera pilicornis* and *Pterostichus strenuus*. *Carabus violaceus* and *Cychnus caraboides* were mentioned by Van der Drift (1959) as Dutch forest species. However, he also included our non-forest species *Calathus erratus*, *C. fuscipes*, *C. melanocephalus*, *Pterostichus madidus*, *P. niger*, *P. strenuus* and the borderline species *P. quadrifoveolatus*. Loreau (1984a, b, c, 1985), studying the carabid fauna of forests in Belgium, reported several forest species that were not classified as such by our method, e.g. *Asaphidion flavipes* (Linnaeus) and *Loricera pilicornis*.

Generally, ecological characterization of species is based on faunistic studies: species that are abundant in a certain habitat, are said to be characteristic for that habitat. In this way the distribution in biotopes other than those under study, is not considered. This seems an important drawback. The present method, on the contrary, does take into consideration the species distribution in many types of habitats. This may be one of the most important reasons for the observed differences we discussed above. These differences may also be due for some part to regional variations.

Criteria used for ecological characterizations should be explicitly formulated in order to be able to evaluate the validity of the typology for a larger area. Moreover these characterizations should be based on large amounts of data. Therefore we recommend our classification of forest species as useful for the Dutch situation.

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REFERENCES

- Boer, P. J. den, 1963. Lebeort (Habitat)-Bindung einiger Waldcarabidenarten in Drente (Holland) in Zusammenhang mit Waldtypus, Boden und Strukturelemente des Waldes (Paper read at Coenol. Symp., Zagreb 9/14-9 1963). - Edition (Comm. 115) of Biological Station Wijster.
- Boer, P. J. den, 1968. Zoological research at the Biological Station, Wijster, 1959-1967. - Miscellaneous Papers Landbouwhogeschool Wageningen 2: 161-181.
- Boer, P. J. den, 1977. Dispersal and survival. Carabids in a cultivated countryside (with a mathematical appendix by J. Reddingius). - Miscellaneous Papers Landbouwhogeschool Wageningen 14: I-II, 1-190.

- Drift, J. van der, 1959. Field studies on the surface fauna of forests. – *Bijdragen tot de dierkunde* 29: 79-103 (ITBON mededeling nr. 41).
- Heckendorf, Chr., A. Ruprecht, K. Schneider & F. Tietze, 1986. Zur Faunenstruktur (Coleoptera-Carabidae) in Wald-Brachland Habitaten des NSG Lintbusch (I58). – *Hercynia* N.F. 23:72-82.
- Heijerman, Th. & H. Turin, in prep. The carabid fauna of different types of dry forests in the Netherlands. – in prep.
- Lauterbach, A.W., 1964. Verbreitungs- und aktivitätsbestimmende Faktoren bei Carabiden in sauerländischen Wäldern. – *Abhandlungen Landesmuseum Naturkunde Münster* 26(4):1-103.
- Lecordier, C. & G. Benest, 1982. Etude d'un écosystème forestier mixte, VI – Les Carabiques (Col.). – *Revue d'Ecologie et de Biologie du sol*, 19(1): 89-104.
- Lindroth, C. H., 1945. Die Fennoskandischen Carabidae. I Spezieller Teil: 1-709 – Göteborg.
- Lindroth, C. H., 1974. Handbook for the identification of British insects Vol.IV. Part 2. Coleoptera, Carabidae: 1-148. – London.
- Lindroth, C. H., 1985. The Carabidae (Coleoptera) of Fennoscandia and Denmark. – *Fauna Entomologica Scandinavica*. Vol. 15, part 1: 1-226.
- Lindroth, C. H., 1986. The Carabidae (Coleoptera) of Fennoscandia and Denmark. – *Fauna Entomologica Scandinavica*. Vol. 15, part 2: 227-498.
- Lohmeyer, W. & W. Rabeler, 1965. Aufbau und Gliederung der mesophilen Laubmischwälder im mittleren und oberen Weser gebiet und ihre Tiergesellschaften. – (Ber. symp. 1960 Stolzenau/Weser), *Biosoziologie* (Tuxen, R., ed.): 238-257, The Hague.
- Loreau, M., 1984a. Composition et structure de trois peuplements forestiers de Carabides. – *Académie royale de Belgique, Bulletin de la classe des sciences*, (5) 70: 125-160.
- Loreau, M., 1984b. Les niches écologiques des Carabides en milieu forestier. I. Composantes spatio-temporelles. – *Académie royale de Belgique, Bulletin de la classe des sciences*, (5) 70: 333-379.
- Loreau, M., 1984c. Les niches écologiques des Carabides en milieu forestier. II. Composante trophique et organisation générale des niches. – *Académie royale de Belgique, Bulletin de la classe des sciences*, (5) 70: 480-524.
- Loreau, M., 1985. Annual activity and life cycles of carabid beetles in two forest communities. – *Holarctic ecology* 8: 228-235.
- Loreau, M., 1986. Niche differentiation and Community Organization in Forest Carabid Beetles. – in: Den Boer et al., *Carabid Beetles, their Adaptations and Dynamics*: 1-551, Stuttgart – New York.
- Rabeler, W., 1962. Die Tiergesellschaften von Laubwäldern (Querc-Fagetea) im oberen und mittleren Wesergebiet. – *Mitteilungen floristisch-soziologischen Arbeitsgemeinschaft*. N.F. 9: 200-229.
- Rabeler, W., 1963. Charakterisierung der Streufauna einiger Nordwestdeutscher Waldgesellschaften – in: Doeken, M. J. & J. v. d. Drift, *Soil organisms*: 1-453, Amsterdam.
- Rabeler, W., 1967. Zur Charakterisierung der Fichtenwald-Biozönose im Harz auf grund der Spinnen- und Käferfauna. – *Schriftreihe für Vegetationskunde* 2: 205-236.
- Rabeler, W., 1969. Zur Kenntnis der nordwestdeutschen Eichen-Birkenwaldfauna. – *Schriftreihe für Vegetationskunde* 4: 131-154.
- Silfverberg, H., 1979 (editor). *Enumeratio Coleopterorum Fennoscandiae et Daniae*: 1-6. – Helsinki.
- Szysko, J., 1983. State of Carabidae (Col.) fauna in fresh pine forest as tentative valorisation of this environment: 1-80. – *Warsaw Agricultural University Press*, Warsawa.
- Thiele, H. U., 1977. Carabid Beetles in their Environments. A Study on Habitat Selection by Adaptations in Physiology and Behaviour: I-XVIII, 1-369. – *Zoophysiology and Ecology* 10, Berlin-Heidelberg-New York.
- Tol, J. van, 1979. Handleiding en atlas voor het medewerken aan entomologische projecten in het kader van de European Invertebrate Survey, Nederland. – 1-60 (+ 37 maps), Leiden.
- Turin, H., J. Haeck & R. Hengeveld, 1977. Atlas of the carabid beetles of The Netherlands. – *Verhandelingen der Koninklijke Nederlandse Academie van Wetenschappen, afd. Natuurkunde* (2). 68: 1-228, Amsterdam.
- Turin, H. & E. Penterman, 1985. Dertig jaar loopkeveronderzoek met vangpotten. – *Nieuwsbrief E.I.S.-Nederland* 16: 35-46.